Virtual Experiment

Effects of extracellular ions and drugs on isolated toad heart

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http://10.71.121.151/physiology/experiment/int/index.asp
Introduction
Why use the isolated heart?

• Isolated toad heart will continue to beat for several hours. No external stimulation (include the nerve and hormone) is required to maintain the heartbeat.

• With the isolated heart model, it is more easier to understand the drug’s direct effect on heart.
Effects of ions in extracellular solution

- **Ringer’s solution (mM):** NaCl 110, KCl 2, NaHCO$_3$ 2.4, NaH$_2$PO$_4$ 0.1, CaCl$_2$ 1
- **0.65% NaCl (mM):** NaCl 110
  No Ca$^{2+}$ will flux into the cardiomyocyte during the action potential (AP). Muscle cell cannot contract.
- **Ringer’s solution with high K$^+$ concentration (mM):** NaCl 110, KCl 5.5, NaHCO$_3$ 2.4, NaH$_2$PO$_4$ 0.1, CaCl$_2$ 1
  High K$^+$ concentration in extracellular solution will decrease the value of resting potential (depolarization) on cardiomyocytes, cause Na$^+$ channel inactivation. It also decreases Ca$^{2+}$ influx in cell to inhibit the muscle contraction.
- **Ringer’s solution with high Ca$^{2+}$ concentration (mM):** NaCl 110, KCl 2, NaHCO$_3$ 2.4, NaH$_2$PO$_4$ 0.1, CaCl$_2$ 5
  Extracellular Ca$^{2+}$ will increasingly flux into cardiomyocytes during AP due to the much higher Ca$^{2+}$ concentration in extracellular solution.
Effects of some drugs in extracellular solution

- **Acetylcholine**: Acetylcholine (Ach) is released by the parasympathetic nervous system. It will inhibit the heart activity by activating the muscarinic acetylcholine receptors on heart.

- **Atropine**: A plant alkaloid that blocks muscarinic acetylcholine receptors.

- **Adrenalin**: Adrenaline (Adr), also called epinephrine, is released by adrenal medulla. It has the same effects as norepinephrine, a neurotransmitter released by post-ganglionic sympathetic nerves. It will increase the heart activity by activating the β type adrenergic receptors on heart.

- **Propranolol**: An antagonist of Type β adrenergic receptors.
Methods
Experimental animal

Toad (Bufo Arenarum Hensel)
Step 1

- Pithing the toad: destroy the brain and spinal cord by means of a needle inserted into the cranial cavity and the vertebral canal.
Step 2

Open the chest
Step 3

- Straub's intubation.
Step 4

Setup the equipments
• select experiment 9 on the catalog list

**CATALOGUE**

• EXP 9 Effects of several drugs and extracellular ions on isolated toad heart

• EXP 10 Aortic nerve firing

• EXP 11 Human electrocardiogram

• EXP 12 Nervous and humoral regulation of arterial blood pressure in rabbit

• EXP 13 Carotid baroreceptor reflex

• EXP 14 Electrical activity of diaphragm muscle and respiration

• EXP 15 Regulation of respiration in rabbit

• EXP 16 Effects of several drugs and extracellular pH on isolated small intestinal muscle

• EXP 17 Factors affecting urine formation

EXIT (NEXT)
Computer operating

- Select the simulation expriment to start work
• An isolated toad’s heart is beating rhythmically on the left side. The beating heart pulls the transducer and a trace is recorded. All the solutions with ions and drugs can be added to heart tube from the bottles.
Computer operating

- Click “Measure” on the recorder to measure the amplitude of contraction to calculate the developing tension.
Results
Data recording

Developing tension = 6.4 - 1.1 = 5.3 g

Tension at the end of diastole = 1.1 g

Interval between the contraction A and B = 2.2 s
Heart rate = 60 / 2.2 = 27 bpm
# Data analyse

Table 1. Effects of extracellular ions and drugs on heart rate and developing tension and the tension of the end of diastole

<table>
<thead>
<tr>
<th></th>
<th>Heart rate (bpm)</th>
<th>Developing tension (g)</th>
<th>Tension of the end of diastole (g)</th>
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</thead>
<tbody>
<tr>
<td>Ringer’s solution</td>
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<td></td>
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<tr>
<td>0.65% NaCl</td>
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<tr>
<td>Ca$^{2+}$</td>
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<tr>
<td>K$^+$</td>
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<tr>
<td>Adrenalin (Adr)</td>
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<td></td>
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<tr>
<td>Propranolol+Adr</td>
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<td></td>
<td></td>
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<tr>
<td>Ach</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Atropine+Ach</td>
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</tbody>
</table>

**Note:** Fill in the raw data on the first blank line, and fill in increase or decrease in the other blank lines.
Discussion
• How was the heart activity affected by increased K⁺ concentration in extracellular solution?
• How was the heart activity affected by increased or decreased Ca²⁺ concentration in extracellular solution?
• Please describe the mechanism by which the following drugs affect heart activity.
  Ach;
  Atropine followed by Ach;
  Adr;
  Propranolol followed by Adr.
Experiment Report

Title of experiment

Your name, registration number, date, Lab room#

1. Objective

2. Results

3. Conclusion & Discussion